

California Environmental Protection Agency



Air Resources Board

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TP - 933

**DRAFT - Test Procedure for Determining Evaporative
Emissions from Off-Highway Recreational Vehicles (OHRVs)**

Adopted: _____, _____

TP-933
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TP-933

Test Procedure for Determining Evaporative Emissions from Off-Highway Recreational Vehicles (OHRVs)

1 Applicability

TP-933 is used by the Air Resources Board to determine OHRV evaporative emissions. This test procedure is proposed pursuant to Section 43824 of the California Health and Safety Code (CH&SC).

1.1 Terms and Definitions

This test procedure incorporates by reference the definitions set forth in the "CALIFORNIA EVAPORATIVE EMISSION STANDARDS AND TEST PROCEDURES FOR 2001 AND SUBSEQUENT MODEL MOTOR VEHICLES;" as amended March 22, 2012, and Title 13, California Code of Regulations (CCR) section 2417, including the incorporated definitions therein from the Code of Federal Regulations (CFR) and the CCR. In addition, the following definitions apply:

- 1.1.1 For the purpose of this procedure, the term "ARB" refers to the California Air Resources Board.
- 1.1.2 For the purpose of this procedure, the term "Executive Officer" refers to the ARB Executive Officer or his or her authorized representative or designate.
- 1.1.3 For the purpose of this procedure, when the term "Administrator" is used in any federal regulations referenced within this document, it shall mean the ARB Executive Officer or his or her authorized representative or designate.
- 1.1.4 For the purpose of this procedure, when the term "methanol" is used in any federal regulations referenced within this document, it shall mean methanol and/or ethanol, except as otherwise indicated in this test procedure.
- 1.1.5 For the purpose of this procedure, the term "horizontal plane" shall mean:
 - 1.1.5.1 For vehicles with two wheels, the plane which contains the line defined by the points where the vehicle's front and rear tires are in contact with the testing surface when positioned in normal upright riding position on the level testing surface and which is parallel to the axis of the wheel axles.
 - 1.1.5.2 For vehicles with three or more wheels, the plane defined by the points where the vehicle's tires contact the testing surface while the vehicle is positioned in normal upright riding position on the level testing surface with the tires inflated to normal manufacturer recommendations.
- 1.1.6 For the purpose of this procedure, the term "travel axis" shall mean the axis defined by the direction the vehicle travels while in normal use defined by the points where the center front and rear tires contact the horizontal plane with the tires inflated to normal manufacturer recommendations. For vehicles with more than one front or rear tire, midpoints between the front and/or rear sets of tires shall be used. Under normal use conditions, this axis will rest in the horizontal plane.
- 1.1.7 For the purpose of this procedure, the term "upright axis" shall mean a line passing through the travel axis which is perpendicular to the horizontal plane. Under normal use conditions, this is the same as the vertical axis.

1.2 Test Data Availability

The manufacturer shall provide the specific information that supports its assurance of the system's performance with the requirements within this procedure within 30 days of a written request by the Executive Officer.

1.3 Safety

This test procedure involves the use of flammable materials and should only be used by, or under the supervision of, those familiar and experienced in the use of such operations and materials. Appropriate safety precautions should be observed at all times while performing this test procedure.

1.4 Test Fuel Specification

The test fuel used for all parts of this procedure unless otherwise specified shall be California Certification Gasoline as specified in "CALIFORNIA 2015 AND SUBSEQUENT MODEL CRITERIA POLLUTANT EXHAUST EMISSION STANDARDS AND TEST PROCEDURES AND 2017 AND SUBSEQUENT MODEL GREENHOUSE GAS EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES" section II.A.100.3.1.2 as adopted March 22, 2012.

1.5 Alternative Test Procedures

With prior approval alternative test procedures can be used. It must be demonstrated that the alternative method is equivalent to or more stringent than the method set forth in this test procedure.

2 Principal and Summary of Test Procedures

This test procedure measures evaporative emissions from a complete vehicle or piece of equipment with complete evaporative emission control systems as defined in 13 CCR 2752 (a)(8) by subjecting them to durability tests, preconditioning, and a diurnal evaporative test as described in section 6 of this procedure. The engine with complete evaporative emission control system must be tested as a complete vehicle except where a test rig is explicitly allowed. Where not otherwise specified, the vehicle shall be approximately level during all phases of the test sequence.

Prior to evaporative emissions testing, the vehicle's evaporative emissions control system must undergo durability testing to ensure that the emissions control devices continue to function as designed for the useful life of the vehicle and it must be preconditioned in a way that simulates real world end of life emissions

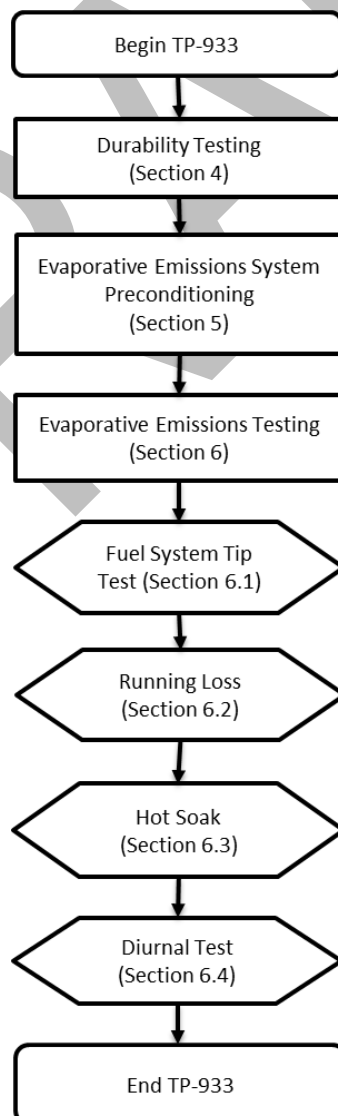
Evaporative emissions are quantified by direct measurement or by a combination of direct measurement and calculation. Evaporative emissions are directly measured with a hydrocarbon analyzer in a sealed testing enclosure following a temperature profile and maintaining atmospheric pressure. The volume of the enclosure must be accurately determined whenever hydrocarbons are being measured. The total mass of hydrocarbons from a test vehicle over the test period is calculated based on concentration, molecular weight, and volume.

The vehicle shall demonstrate adequate control of diurnal emissions through one of the following test sequences:

Vehicle may undergo a 72 hour diurnal evaporative emissions test with variable temperature as defined in with section 6.4.1.

As an alternative a steady state diurnal test may be used to show compliance. The vehicle's evaporative emissions control system is demonstrated to be adequately designed and constructed by performing a 24 hour diurnal test in conjunction with the vented emissions requirements as described section 6.4.2. The steady state diurnal test must be conducted at a constant temperature of 86 ± 3 °F with a vent connecting the evaporative vent to the atmosphere outside the SHED enclosure. The purpose of the steady state diurnal test is to evaluate permeation and verify the construction of the evaporative emissions control system. Compliance is shown with the vented emissions requirement using the Calculation Method as described in Appendix B or by using a pressure relief valve that opens at 2 psi or greater, or which does not release vapor from the tank during the second of two consecutive 24 hour diurnal temperature cycles from 72° to 96°F. An overview of the procedure is shown in the following flow chart:

Figure 1: TP-933 Summary Flowchart



3 Instrumentation

Equipment used during this testing shall, at a minimum, meet the requirements set forth in this section.

3.1 Vehicle Test Enclosure

Refer to "CALIFORNIA EVAPORATIVE EMISSION STANDARDS AND TEST PROCEDURES FOR 2001 AND SUBSEQUENT MODEL MOTOR VEHICLES" adopted August 5, 1999, amended March 22, 2012, Parts III. A and III.B, included here by reference, for evaporative emission measurement enclosure requirements and calibrations with the following exception(s):

- 3.1.1 For, diurnal evaporative tests, and tip test the fuel tank temperature is not controlled in this procedure. Fuel tank temperature is only controlled for the pressure relief option in section 6.4.2. Therefore, disregard all sections pertaining to fuel tank temperature monitoring and fuel tank temperature management systems except as required.

- 3.1.1.1 If showing compliance with a pressurized fuel tank revise subparagraph 40 CFR §86.107-90(a)(5) (Temperature Recording System) to read: In addition to the specifications in this section the vapor temperature in the fuel tank must be measured. When the fuel or vapor temperature sensors cannot be located in the fuel tank to measure the temperature of the prescribed test fuel or vapor at the approximate mid-volume (e.g. saddle tank), sensors shall be located at the approximate mid-volume of each fuel or vapor containing cavity. The average of the readings from these sensors shall constitute the fuel or vapor temperature. The Executive Officer may approve alternate sensor locations where the specifications above cannot be met or where tank symmetry provides redundant measurements.

3.2 Dynamometer

- 3.2.1 The chassis dynamometer shall meet the requirements of 40 CFR §86.508-78, 40 CFR 86.108-00, or 40 CFR 86.108-79 as long as it is capable of accurately simulating the test weight of the vehicle.
- 3.2.2 The chassis dynamometer shall be calibrated according to the requirements used in 3.2.1 above. The calibration shall be conducted at a temperature of 86°F ± 3°F.

3.3 Fuel Vapor Hydrocarbon Analyzer

The fuel vapor hydrocarbon analyzer shall meet the requirements specified in 40 CFR §86.107-90(a)(2)(i) and the fuel vapor alcohol analyzer shall meet the requirements specified in 40 CFR §86.107-90(a)(2)(ii). As described in Appendix A, ethanol measurements may be omitted if the calculated mass of hydrocarbon emissions is multiplied by an adjustment factor that accounts for alcohol vapor.

3.4 Test Data Recording System

An on-line computer system or strip-chart recorder shall be used to record the following parameters during the test sequence:

- a) Cell/enclosure ambient temperature
- b) If applicable temperatures of vehicle fuel tank liquid (T_{liq}) and vapor space (T_{vap})
- c) If applicable vehicle fuel tank headspace pressure
- d) Dynamometer roll speed (if applicable)
- e) FID output voltage recording the following parameters for each sample analysis:
 - 1) zero gas and span gas adjustments
 - 2) zero gas reading
 - 3) dilute sample bag reading (if applicable)
 - 4) dilution air sample bag reading (if applicable)
 - 5) zero gas and span gas readings
- f) Ethanol sampling data including:
 - 1) the volumes of deionized water introduced into each impinge
 - 2) the rate and time of sample collection
 - 3) the volumes of each sample introduced into the gas chromatograph
 - 4) the flow rate of carrier gas through the column
 - 5) the column temperature
 - 6) the chromatogram of the analyzed sample

3.5 Carbon Canister Bench Aging Equipment

Carbon canister bench aging equipment shall meet the requirements specified in section 4.1 of this procedure.

3.6 Carbon Canister Test Bench

The carbon canister test bench or associated combination of testing equipment shall meet the requirements specified in section 5.2 of this procedure.

4 Durability Testing

Certification of an OHRV evaporative emission control system requires that the manufacturer demonstrate the durability of each evaporative emission control system family. A demonstration of durability of the applicant's evaporative emission control system is required prior to performing the evaporative emissions test described in section 6. Completing a durability demonstration prior to evaporative emissions testing ensures that the vehicle will meet evaporative emissions standards over the useful life of the vehicle. In the case where an evaporative emission control system has not undergone durability testing for exhaust testing as prescribed in the *CALIFORNIA EXHAUST EMISSIONS STANDARDS AND TEST PROCEDURES FOR 1997 AND LATER OFF-HIGHWAY RECREATIONAL VEHICLES AND ENGINES* as amended July 16, 2007, the evaporative emissions control system must satisfy the applicable durability requirements of that procedure before proceeding to the durability testing section of this procedure unless each evaporative emissions-related part has undergone durability testing for exhaust testing in another model of vehicle.

In addition, OHRV manufacturers must comply with the durability requirements in section 4.1-4.3 of this test procedure or get approval for ARB for an alternative durability procedure. Determination of an evaporative emissions Deterioration Factor (DF) is defined as the vehicle evaporative emissions before durability testing divided by the evaporative emissions after performing durability testing. Carry-over and carry-across of DFs may be allowed for systems using components that have successfully completed durability testing.

Applicants shall be allowed to proceed to section 5 of this test procedure if they remain free of defects after the durability tests prescribed below. An applicant may propose modifications to the durability tests in this section if they can clearly demonstrate that the alternative durability test procedures are representative of end of useful life.

The durability test must include the following steps:

4.1 Carbon Canister Test

For systems that utilize a carbon canister, the durability test procedure(s) shall include thermal cycling and vibration exposure of the canister.

4.1.1 For thermal cycling, the test must subject the canister to 100 cycles of the following temperature profile:

4.1.1.1 Heat and hold at $60\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for 30 minutes. (Up to 10 minutes is allowed for the temperature to rise and stabilize.)

4.1.1.2 Cool and hold at $0\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for 30 minutes. (Up to 20 minutes is allowed for the temperature to reach $0\text{ }^{\circ}\text{C}$ during the cooling period.)

4.1.2 For the vibration test the canister must be subject to a peak horizontal force of 4.5G at 60Hz with a total of 10^7 cycles. The orientation of the canister while being subject to vibration must be the same as when mounted on the vehicle during normal use. If the canister is mounted on the vehicle using a vibration isolation system, the canister may be mounted in a test rig using the same vibration isolation system for the conduct of the test.

4.2 Pressure Vent Valve

If the fuel system employs a fuel vapor pressure vent valve, prior to the time of submission of a certification application the applicant is required to submit and obtain approval of an evaporative emission durability test procedure for the pressure vent valve. The procedure shall have provisions to demonstrate durability after exposure to UV light, ozone, vibration and dust. Once approved, the pressure vent valve durability procedure may be used by any applicant using a similar pressure vent valve.

4.3 Carbon Canister Protection - Tip Test

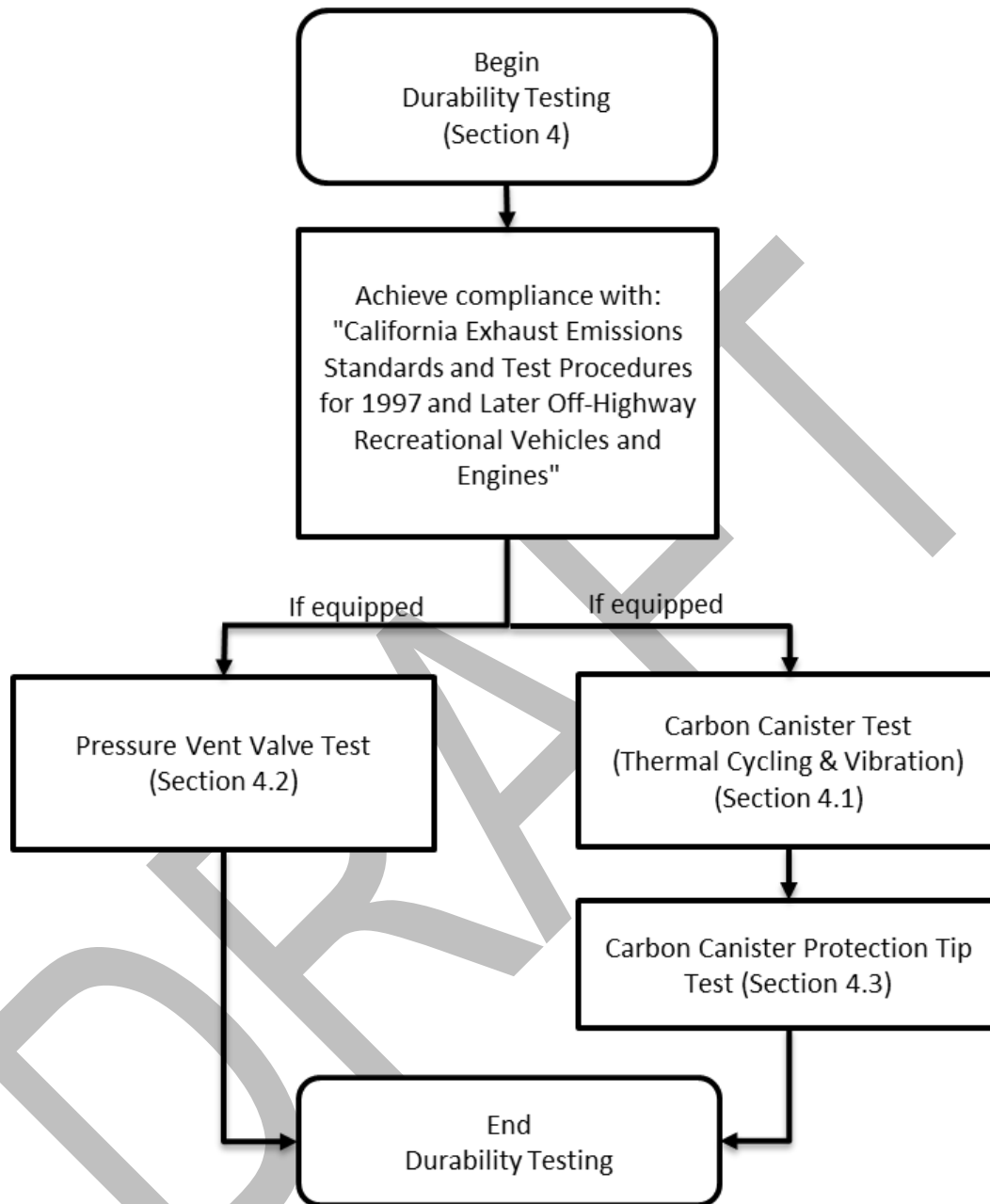
The carbon canister protection tip test can be conducted with a vehicle or with a test rig that represents the actual position and orientation of the fuel system components. The fuel tank must be filled to 100% of nominal capacity with certification fuel.

- 4.3.1 Orient the vehicle such that the travel axis is tilted +and- X degrees above the horizontal plane. See Figure 6 below. Hold this position in both the positive and negative position for at least 1 minute each. X shall be as defined as follows:
- a) $30 \pm 2^\circ$ for off-road motorcycles.
 - b) $30 \pm 2^\circ$ for all other OHRVs.
- 4.3.2 Orient the vehicle such that the upright axis is tilted Y degrees from the vertical axis with rotation being about the travel axis. See Figure 7 below. Hold this position in both the positive and negative position for at least 1 minute each. Y shall be as defined as follows:
- a) Unsupported position on either side for off-road motorcycles.
 - b) $15 \pm 2^\circ$ for all other OHRVs.

Vehicles must measure canister weight before and after the tests specified in this section to determine weight gain. If the weight gain is 10% of the butane working capacity or more, the vehicle fails the test.

Alternative carbon canister protection tip tests may be submitted for approval. All proposed alternatives to the carbon canister protection tip test must show that the carbon canister functions as it should at the end of useful life while subjecting it to the potential for liquid gasoline contamination consistent with vehicle usage. As a guideline all alternative carbon canister tip test should include real world liquid fuel exposure (e.g. volumes, rates, and total events), real world purges (e.g. rates, and bed volumes), and use of a damaged canister during testing described in this procedure.

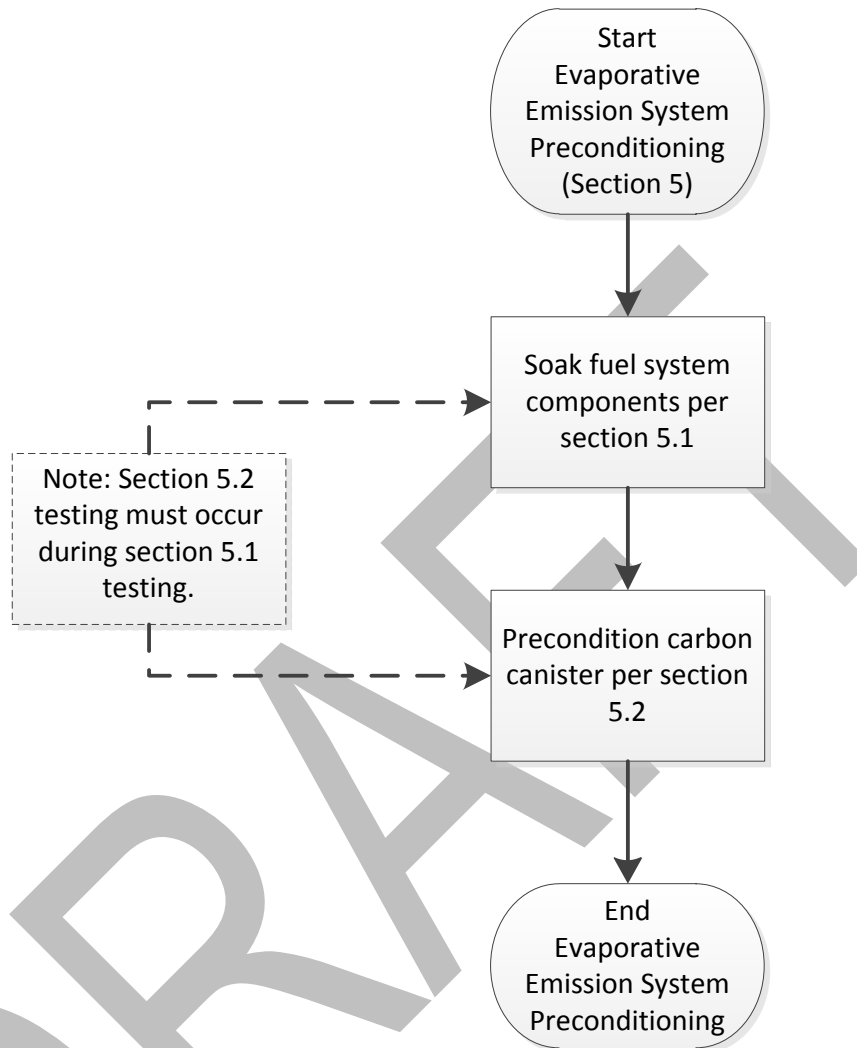
Figure 2: Durability Flow Chart



5 Evaporative Emissions System Preconditioning

The purpose of the preconditioning period is to introduce test fuel into the fuel system and condition all fuel system components to in-use conditions. Evaporative system preconditioning can be done in conjunction with mileage accumulation for exhaust testing as long as the fuel system has continuously held evaporative test fuel (E10, 10% ethanol) fuel in it for a total 140 days. The preconditioning procedure is demonstrated by the flow chart below and shall include the following steps:

Figure 2: Preconditioning Flowchart



5.1 Soak Fuel System Components

Precondition the tank and other fuel delivery system components by filling the tank to its nominal capacity with fresh test fuel and cap within one minute of filling. After filling the tank start the engine and allow it to run at an idle for approximately fifteen minutes. Soak the tank and other components continuously for a total of 3,360 hours while maintaining an ambient temperature between 68°F and 86°F. Alternatively, components may be preconditioned using a fuel system test rig. The test rig must include all the components of the fuel and evaporative emissions control system connected and oriented as they would be installed in the vehicle. The tank and fuel lines must be filled with certification fuel at the beginning of the test. A fuel system may be soaked for less than 3,360 hours if data is provided using TP-901 (CARB SORE evap) or 40 CFR 1060.520 that shows steady state permeation has been reached. If slosh testing is required, the slosh time may be considered part of the preconditioning period provided all fuel system components tested remain filled with fuel and are never empty for more than one hour over the entire preconditioning period.

If the fuel system is allowed to sit more than 6 weeks at 68°F to 86°F, a 1 week presoak must be conducted with fresh fuel before testing begins. The fresh fuel presoak can be counted as part of the 3360 hour soak, so long as the fuel system is empty less than one hour.

Prior to beginning any test sequence to measure running loss, hot soak, or diurnal emissions, a vehicle may, at the manufacturer's option, be preconditioned to minimize non-fuel emissions by being soaked at an elevated temperature prior to testing. To ensure steady state permeation rates the vehicle must be soaked for at least 7 days at a temperature no higher than 95°F immediately prior to emissions testing.

5.2 Precondition Carbon Canister

For systems that utilize carbon canisters, 5.2.2 through 5.2.4 of the preconditioning sequence must be completed no sooner than 96 hours preceding the beginning of the evaporative emission test procedure described in section 6 at 86 ± 3 °F.

For vehicles with multiple canisters in a series configuration, the set of canisters must be preconditioned as a unit. For vehicles with multiple canisters in a parallel configuration, each canister must be preconditioned separately. If production evaporative canisters are equipped with a functional service port designed for vapor load or purge steps, the service port shall be used to precondition the canister.

The following steps shall be performed in preconditioning the carbon canister:

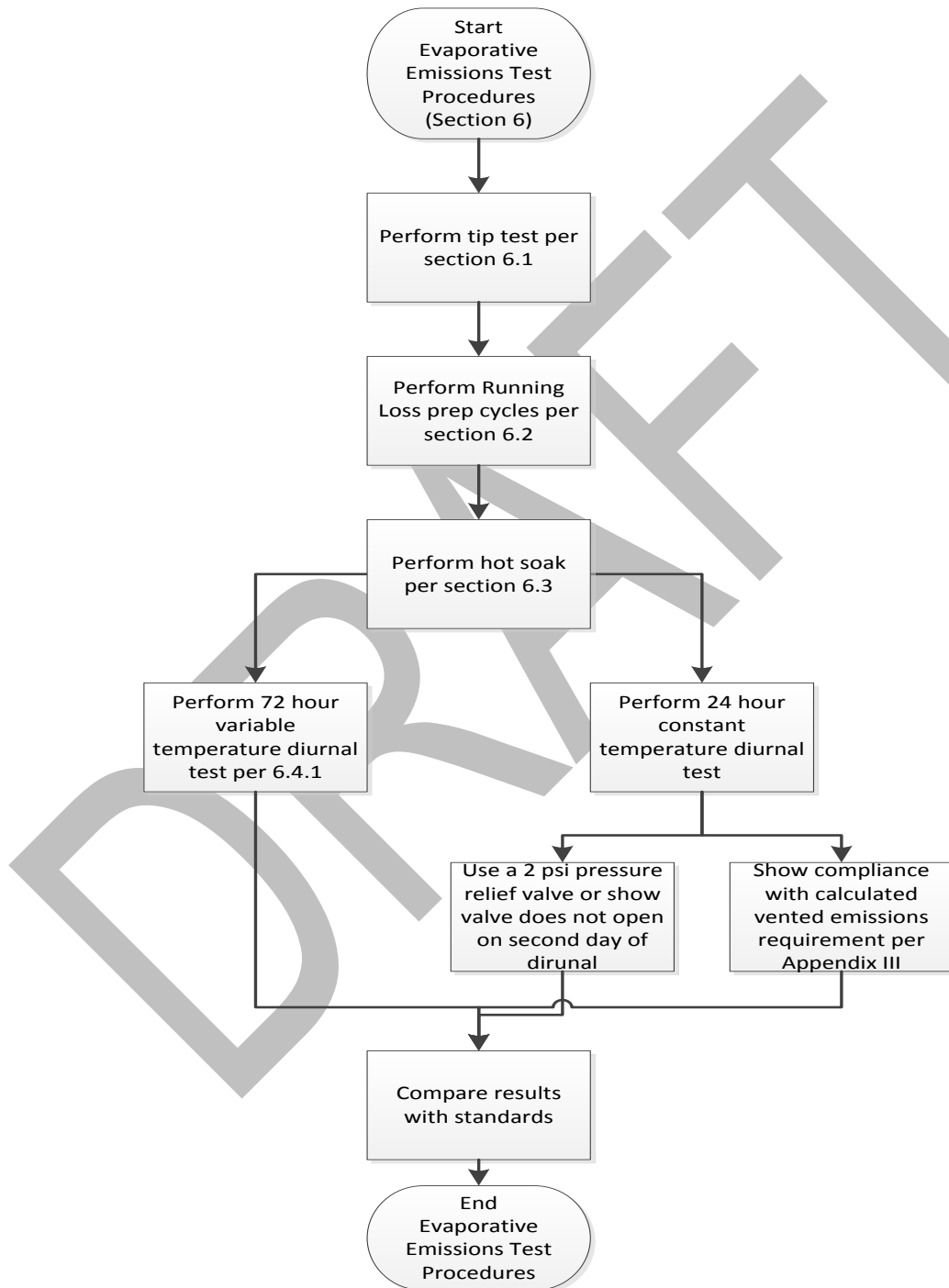
- 5.2.1 Determine the canister's nominal working capacity based on the average capacity of no less than five canisters. These five canisters shall be the same as the canister on the vehicle undergoing testing. A manufacturer may use the butane working capacity provided by the canister vendor if the vendor certifies that the working capacity has been determined using the following procedures:
 - a) Each canister must be loaded no less than 10 times and no more than 100 times to 2-gram breakthrough with a 50/50 mixture by volume of butane and nitrogen, at a rate of 15 ± 2 grams butane per hour per liter of canister volume. Each canister loading step must be preceded by canister purging with 300 canister bed volume exchanges at 0.8 cubic feet per minute (cfm) per liter of canister volume.
 - b) Each canister must first be purged with 300 canister bed volume exchanges at 0.8 cfm per liter of canister volume. The working capacity of each canister shall be established by determining the mass of butane required to load the canister from the purged state so that it emits 2 grams of hydrocarbon vapor; the canister must be loaded with a 50/50 mixture by volume of butane and nitrogen, at a rate of 15 ± 2 grams butane per hour per liter of canister volume.
- 5.2.2 Prepare the vehicle's evaporative emission canister for the canister purging and loading operation. The canister shall not be removed from the vehicle, unless access to the canister in its normal location is so restricted that purging and loading can only reasonably be accomplished by removing the canister from the vehicle. Special care shall be taken during this step to avoid damage to the components and the integrity of the fuel system. A replacement canister may be temporarily installed during the soak period while the canister from the test vehicle is preconditioned.

- 5.2.3 The canister purge shall be performed with ambient air of humidity controlled to 50 ± 25 grains per pound of dry air. This may be accomplished by purging the canister in a room that is conditioned to this level of absolute humidity. The flow rate of the purge air shall be maintained at a nominal flow rate of 0.8 cfm per liter of canister volume and the duration shall be determined to provide a total purge volume flow through the canister equivalent to 300 canister bed volume exchanges. The bed volume is based on the volume of adsorbing material in the canister.
- 5.2.4 The evaporative emission canister shall then be loaded by sending to the canister an amount of commercial grade butane vapors equivalent to 1.5 times its nominal working capacity. The canister shall be loaded with a mixture composed of 50 percent butane and 50 percent nitrogen by volume at a rate of 15 ± 2 grams butane per hour per liter of canister volume. If the canister loading at that rate takes longer than 12 hours, a manufacturer may determine a new rate, based on completing the canister loading in no less than 12 hours. The new rate may be used for all subsequent canister loading within this preconditioning. The time of initiation and completion of the canister loading shall be recorded.

6 Evaporative Emissions Test Procedures

The Evaporative Emissions Test Procedures are demonstrated by the flow chart below and shall include the following steps:

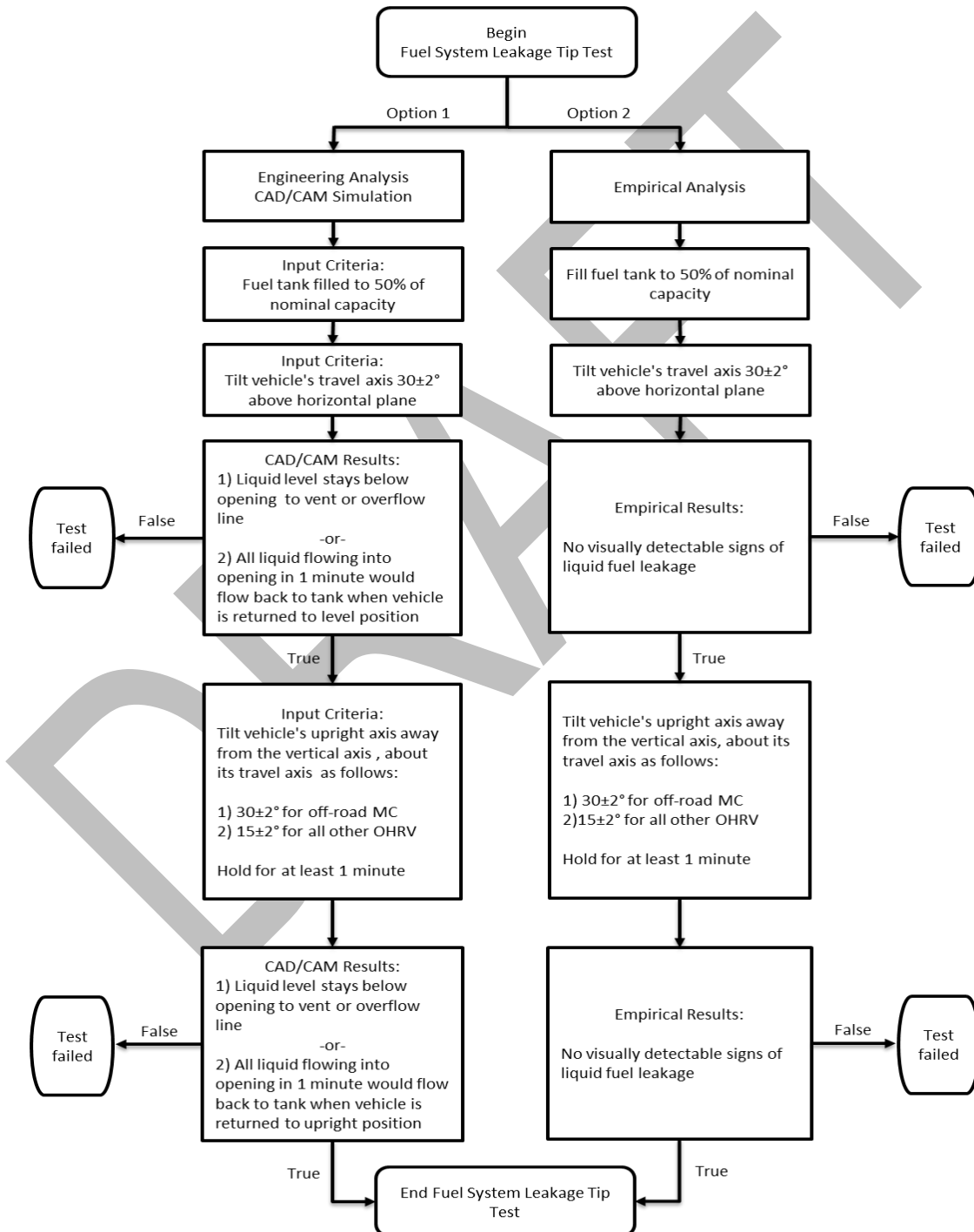
Figure 4: Evaporative Emissions Testing Flowchart



6.1 Fuel System Leakage - Tip Test

The fuel system leakage tip test shall be performed during the soak specified in 6.2.1.5 below. The fuel tank must be filled to 50% with certification fuel. During the test the vehicle is tipped to inspect for visible signs of liquid leakage. If any test fuel leakage is observed then the vehicle fails the test. See Figure 5 below.

Figure 5: Fuel System Leakage Tip Test Flow Chart



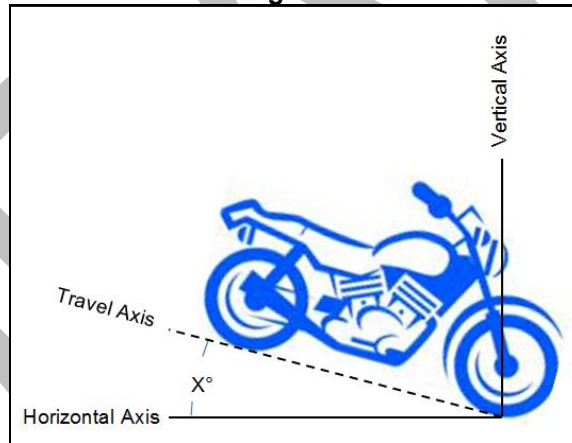
An engineering analysis may be performed as an alternative to the tests described in this section. The analysis must demonstrate that zero liquid leakage will occur within one minute when the vehicle, with the gasoline tank filled to 50% of rated capacity, is tipped as specified in 6.1. To perform the analysis, a CAD/CAM design program may be used to determine the level of fuel in the system that would occur when the tank is filled to 50% of its nominal capacity. To demonstrate compliance, the height of the fuel surface when the vehicle is tilted must be below the height of any opening to a vent or overflow line or it must be demonstrated that the total volume of fuel flowing into the opening in one minute would flow back into the fuel tank when the vehicle is returned to a level surface.

All tip measurements shall be made to an accuracy of $\pm 1^\circ$ of arc.

The tip test shall be conducted with vehicle on a level surface as follows:

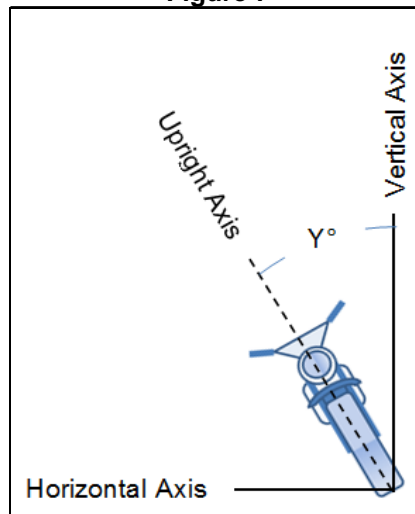
- 6.1.1 Orient the vehicle such that the travel axis is tilted +and- X degrees above the horizontal plane. See Figure 6 below. Hold this position in both the positive and negative position for at least 1 minute each. Note any visible signs of fuel leakage. X shall be as defined as follows:
- a) $30 \pm 2^\circ$ for off-road motorcycles.
 - b) $30 \pm 2^\circ$ for all other OHRVs.

Figure 6



- 6.1.2 Orient the vehicle such that the upright axis is tilted +and- Y degrees from the vertical axis with rotation being about the travel axis. See Figure 7 below. Hold this position in both the positive and negative position for at least 1 minute each. Y shall be as defined as follows:
- a) $30 \pm 2^\circ$ for off-road motorcycles.
 - b) $15 \pm 2^\circ$ for all other OHRVs.

Figure 7



6.2 Running Loss Conditioning

The running loss test is designed to simulate vehicle operation and canister purging during operation. Follow the dynamometer schedules and in 40 CFR 86.1051.501(b), for the purpose of this running loss conditioning all soak and test temperatures are $86 \pm 3^\circ\text{F}$.

- 6.2.1 The following steps shall be performed before beginning the running loss test:
 - 6.2.1.1 The fuel tank of the vehicle to be tested shall be drained and refilled to 50% with test fuel.
 - 6.2.1.2 Soak at least 6 hours after being refueled. Following this soak period, conduct a refueling cycle by running the test vehicle through one UDDS driving cycle. The drain and fill and 6 hour soak may be omitted on subsequent tests of the vehicle if the vehicle remains under laboratory temperatures between tests. The later test preconditioning will begin with 6.2.1.5.
 - 6.2.1.3 Install fuel temperature sensors as needed.
 - 6.2.1.4 Drain and refill the fuel tank of the vehicle to 50% with test fuel.
 - 6.2.1.5 Soak the vehicle with the key off for 12 to 36 hours between the end of the refueling and the start of the cold start preconditioning cycle.
 - 6.2.1.6 During the soak period, perform the tip test specified in 6.1 and purge and load the evaporative control system canister using the procedures defined in sections 5.2.2, 5.2.3 and 5.2.4.
 - 6.2.1.7 A cooling fan location and speed must comply with the requirements in Appendix C.
 - 6.2.1.8 The speed profile is the EPA Urban Dynamometer Driving Schedule (UDDS) as specified in 40 CFR 86.115-78. The same cycle (class I or class II) must be used as is required for exhaust emissions certification. The steady state engine test for ATVs is not allowed for this test procedure.
 - 6.2.1.9 Perform a cold start UDDS preconditioning cycle on the dynamometer.
 - 6.2.1.10 Turn the engine off for no more than 10 minutes
 - 6.2.1.11 Perform a hot start UDDS preconditioning cycle on the dynamometer.

Following the completion of the running loss preconditioning the vehicle must conduct the hot soak preconditioning as specified in 6.3.

6.3 Hot Soak Conditioning

The hot soak evaporative emission preconditioning is designed to load subject the OHRV to a soak that occurs directly after operation. The test temperature for the hot soak is 86 ± 3 °F.

- 6.3.1 The hot soak must be performed within 7 minutes of the completion of the UDDS hot start cycle, performed in step 6.2.
- 6.3.2 Turn off all engine cooling fans when the engine is turned off.
- 6.3.3 During the time between the end of the UDDS hot start cycle and the beginning of the hot soak preconditioning, the engine is allowed to be shut off for no more than 4 minutes immediately preceding the start of the hot soak preconditioning.
- 6.3.4 Soak the OHRV at 86 ± 3 °F for 90 ± 0.5 minutes.
- 6.3.5 If the Calculation Method is to be used for the diurnal test the carbon canister must be removed immediately following the hot soak test and the butane working capacity must be determined by loading the canister to 2-gram breakthrough with a 50/50 mixture by volume of butane and nitrogen, at a rate of 15 ± 2 grams butane per hour per liter of canister volume.
- 6.3.6 Upon completion of the hot soak test, proceed to the diurnal test in 6.4.

6.4 Diurnal Test

Upon completion of the hot soak, the diurnal test shall begin. The diurnal test can be conducted by direct measurement of 3-24 hour diurnal tests (72 hour diurnal test) or by measuring emissions for a single 24 hour diurnal test and showing vented emissions compliance (steady state diurnal test) as described in section 6.4.1 and 6.4.2 respectively.

6.4.1 72 Hour Diurnal Test

Begin the 3 day diurnal test by lowering the temperature of the enclosure in which the diurnal test will be performed to 72 ± 3 °F within 60 minutes of completing the hot soak test. Diurnal soak period is 6-36 hours at 72 ± 3 °F.

Perform the diurnal test procedure described in 40 CFR §86.133-96, with the following exceptions:

- 6.4.1.1 When the word "methanol" or the term C_{CH_3OH} (methanol concentration) is used, it shall mean respectively ethanol or the term $C_{C_2H_5OH}$ (ethanol concentration).
- 6.4.1.2 All references to the hot soak test performed in 40 CFR §86.138-96 shall mean the hot soak conditioning previously described in section 6.3 of this procedure.
- 6.4.1.3 All references to the calculations performed in 40 CFR §86.143 shall reference the calculations performed in appendix B of this procedure instead.
- 6.4.1.4 Omit the following language from section (a)(1), "The diurnal emission test may be conducted as part of either the three- diurnal test sequence

or the supplemental two-diurnal test sequence, as described in 40 CFR §86.130–96.”

- 6.4.1.5 Omit section (a)(3), and all of sections (j), (o) and (p).
- 6.4.1.6 Omit the following language from section (e), “...and the test vehicle windows and luggage compartment(s) opened...”.
- 6.4.1.7 Revise section (i)(5) as follows, “Within 10 minutes of closing and sealing the test enclosure doors, analyze enclosure atmosphere for hydrocarbons and record. This is the initial (time=0 minutes) hydrocarbon concentration, CHC_i , required in appendix A of this procedure. The final hydrocarbon measurement shall be conducted no more than 60 seconds from the end of the test.”
- 6.4.1.8 Omit the following language from section (n), “...the test vehicle windows and luggage compartments may be closed ...”.

6.4.2 Steady State Diurnal Test

The purpose of the steady state diurnal test is to demonstrate control of permeation emissions and to verify proper evaporative emissions system construction.

- 6.4.2.1 Perform the diurnal test as defined in 6.4.1 except:
- 6.4.2.2 Attach vent line(s) to air-port(s) of carbon canister(s) that will direct any air/vapor exiting the canister to the exterior of the test SHED. This air/vapor need not be measured.
- 6.4.2.3 The test shall be conducted at a constant temperature of 86 ± 3 °F.
- 6.4.2.4 A single steady state 24 hour diurnal is required.
- 6.4.2.5 Compliance is shown if the emissions measured in 6.4.2 are lower than the standard and either of the following can be shown:
 - a) Calculated maximum gasoline vapor loading and show that the carbon canister is operating in the range where it is at least 99.5% effective (0.5% bleed emissions) based on best modeling practices. The best modeling practices method must be accepted by ARB staff prior to certification or follow the requirements in appendix B of this test procedure.
 - b) The OHRV uses a pressure relief valve which does not release vapor from the tank up to 2 psig, or during the second of two consecutive 24 hour diurnal temperature cycles from 72° to 96°F. The fuel temperature must be below the boiling point for test fuel during both the running loss and hot soak conditioning.

7 Calculations: Evaporative Emissions

To determine emissions, apply the calculations given in Appendix A and Appendix B to the data collected in sections 6.2 through 6.4 as needed to show compliance with standards.

8 List of Terms

ARB	California Air Resources Board
$C_{C_2H_5OH}$	Ethanol concentration
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CH&SC	California Health and Safety Code
HC	Hydro- Carbon
MPH	Miles Per Hour

OHRV	Off-Highway Recreational Vehicle
PSIG	Pounds per Square Inch – Gauge
T _{liq}	Fuel tank liquid temperature
T _{vap}	Fuel tank vapor space temperature
TP-933	Test Procedure for determining evaporative emissions from off-highway recreational vehicles
UV	Ultra Violet
UDDS	EPA Urban Dynamometer Driving Schedule

9 References

1. Fuel System Evaporative Loss Control Devices, California Health and Safety Code §43824
2. California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, as amended on March 22, 2012.
3. Definitions, Title 13, CCR §2417
4. California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, as amended on March 22, 2012
5. Definitions, 13 CCR §2752
6. Sampling and analytical system; evaporative emissions, 40 CFR §86.107-90
7. Dynamometer, 40 CFR §86.108-00
8. Dynamometer calibration, 40 CFR §86.118-78
9. California Exhaust Emissions Standards And Test Procedures For 1997 And Later Off-Highway Recreational Vehicles And Engines, California Environmental Protection Agency, Air Resources Board, El Monte, CA, as amended on July 16, 2007.
10. Running loss test, 40 CFR §86.134-96
11. EPA urban dynamometer driving schedule, 40 CFR §86.115-78
12. Sampling and analytical systems; evaporative emissions, 40 CFR §86.107-96
13. Diurnal emission test, 40 CFR §86.133-96
14. Calculations; evaporative emissions, 40 CFR §86.143
15. Test sequence; general requirements, 40 CFR §86.130-96

10 Appendix

10.1 Appendix A – Calculations: Evaporative Emissions

a) The following equations are used to calculate the evaporative emissions from gasoline- and ethanol-fueled vehicles, and for gaseous-fueled vehicles.

b) Use the measurements of initial and final concentrations to determine the mass of hydrocarbons and ethanol emitted. Alternatively, ethanol measurements may be omitted if the calculated mass of hydrocarbon emissions is multiplied by a percentage adjustment factor equal to: $(100\% - 0.5 \times \% \text{ fuel alcohol content}) \times (1 + (\% \text{ ethanol} \times 3))$ (e.g. for E10 adjustment factor = $(100\% - 0.5 \times 10\%) \times 1.3 = 124\%$)

1) For enclosure testing of diurnal, hot soak, and running loss emissions:

(i) Ethanol emissions:

$$M_{C_2H_5OH} = V_n \times \left(\left[\frac{(C_{MS1f} \times AV_{1f}) + (C_{MS2f} \times AV_{2f})}{V_{Ef}} \right] - \left[\frac{(C_{MS1i} \times AV_{1i}) + (C_{MS2i} \times AV_{2i})}{V_{Ei}} \right] \right) + M_{C_2H_5OH,out} - M_{C_2H_5OH,in}$$

Where,

(A) $M_{C_2H_5OH}$ = Ethanol mass change, μg .

(B) V_n = Net enclosure volume, ft^3 , as determined by subtracting 5 ft^3 (1.42 m^3) from the enclosure volume. A manufacturer may use the measured volume of the vehicle (instead of the nominal 5 ft^3) with advance approval by the Administrator. Provided, the measured volume is determined and used for all vehicles tested by that manufacturer.

(C) V_E = Volume of sample withdrawn, ft^3 . Sample volumes must be corrected for differences in temperature to be consistent with determination of V_n , prior to being used in the equation.

(D) C_{MS} = GC concentration of sample, $\mu\text{g}/\text{ml}$.

(E) AV = Volume of absorbing reagent in impinger.

(F) P_B = Barometric pressure at time of sampling, in. Hg.

(G) i = Initial sample.

(H) f = Final sample.

(I) 1 = First impinger.

(J) 2 = Second impinger.

(K) $M_{C_2H_5OH,out}$ = mass of ethanol exiting the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, μg .

(L) $M_{C_2H_5OH,in}$ = mass of ethanol entering the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, μg .

(ii) Hydrocarbon emissions:

$$M_{HC} = (kV_n \times 10^{-4}) \times \left(\frac{(C_{HCf} - rC_{MC_2H_5OHf})P_{Bf}}{T_f} - \frac{(C_{HCi} - rC_{MC_2H_5OH_i})P_{Bi}}{T_i} \right) + M_{HC,out} - M_{HC,in}$$

Where,

(A) M_{HC} = Hydrocarbon mass change, g.

(B) C_{HC} = FID hydrocarbon concentration as ppm including FID response to methanol (or methane, as appropriate) in the sample.

(C) $C_{C_2H_5OH}$ = Ethanol concentration as ppm carbon.

$$C_{C_2H_5OH} = \frac{1.501 \times 10^{-3} \times T}{P_B \times V_E} \times [(C_{s1} \times AV_1) + (C_{s2} \times AV_2)]$$

(D) V_n = Net enclosure volume ft^3 (m^3) as determined by subtracting 5 ft^3 (1.42 m^3) from the enclosure volume. A manufacturer may use the measured volume of the vehicle (instead of the nominal 5 ft^3) with advance approval by the Administrator, provided the measured volume is determined and used for all vehicles tested by that manufacturer.

(E) r = FID response factor to ethanol.

(F) P_B = Barometric pressure, in Hg (Kpa).

(G) T = Enclosure temperature, $^{\circ}\text{R}$ ($^{\circ}\text{K}$).

(H) I = initial reading.

(I) f = final reading.

(J) 1 = First impinger.

(K) 2 = Second impinger.

(L) Assuming a hydrogen to carbon ratio of 2.3:

(1) $k = 2.97$; and

(2) For SI units, $k = 17.16$.

(M) $M_{HC,out}$ = mass of hydrocarbons exiting the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, g.

(N) $M_{HC,in}$ = mass of hydrocarbons entering the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, g.

(iii) For variable-volume enclosures, defined in 40 CFR §86.107(a)(1)(i), the following simplified form of the hydrocarbon mass change equation may be used:

$$M_{HC} = \left(\frac{kP_{\bar{e}}V_{\bar{e}} \times 10^{-4}}{T} \right) \times \left[(C_{HCf} - rC_{C_2H_5OHf}) - (C_{HCi} - rC_{C_2H_5OH_i}) \right]$$

DRAFT

10.2 Appendix B - Calculation Method for demonstrating the adequacies of the Vented Evaporative Emissions system.

The calculations in this section are based on the ideal gas law, and equations generated in *SAE 892089- Prediction of Fuel Vapor Generation From a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature*.

Figure A-1: Calculations Flow Chart

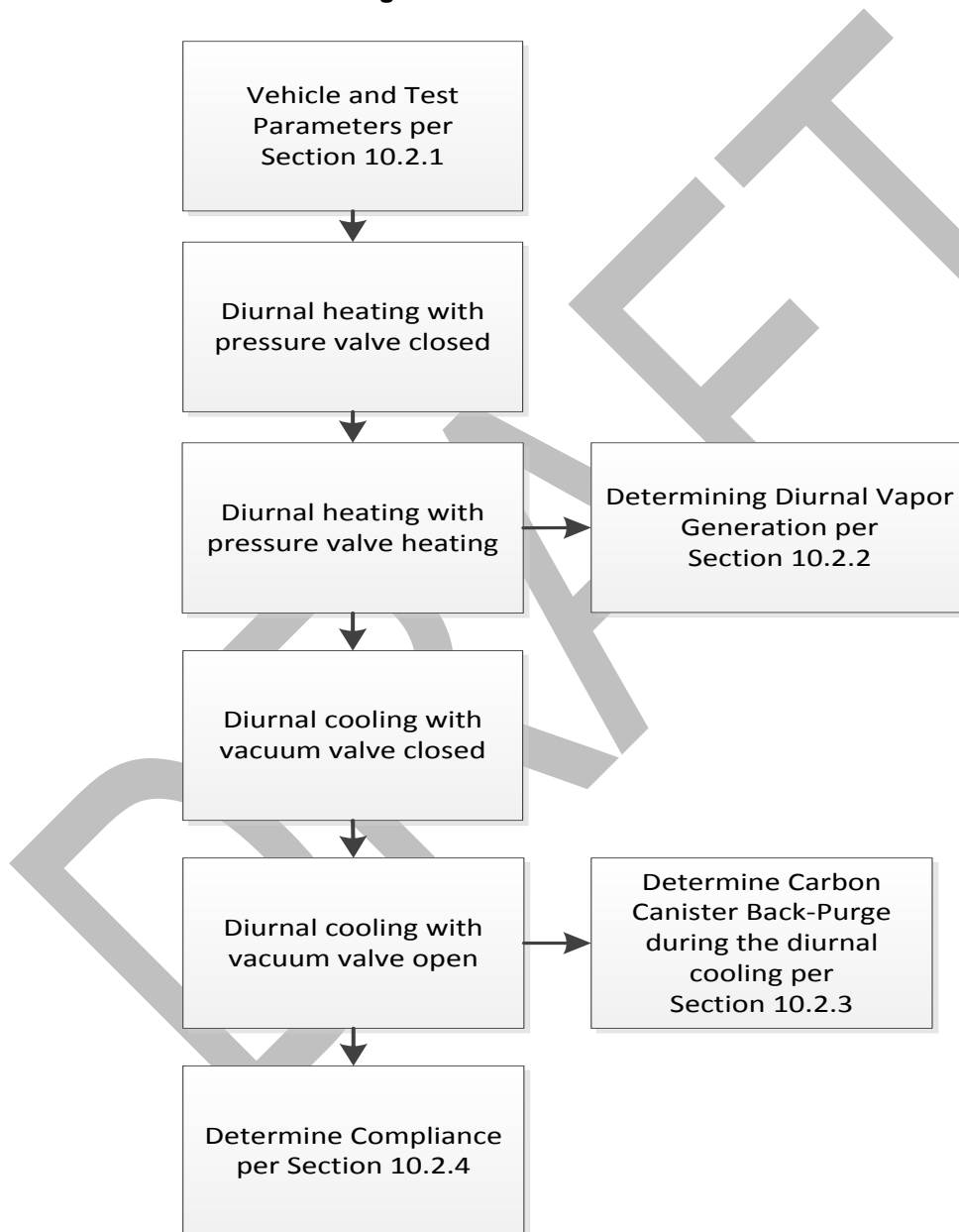
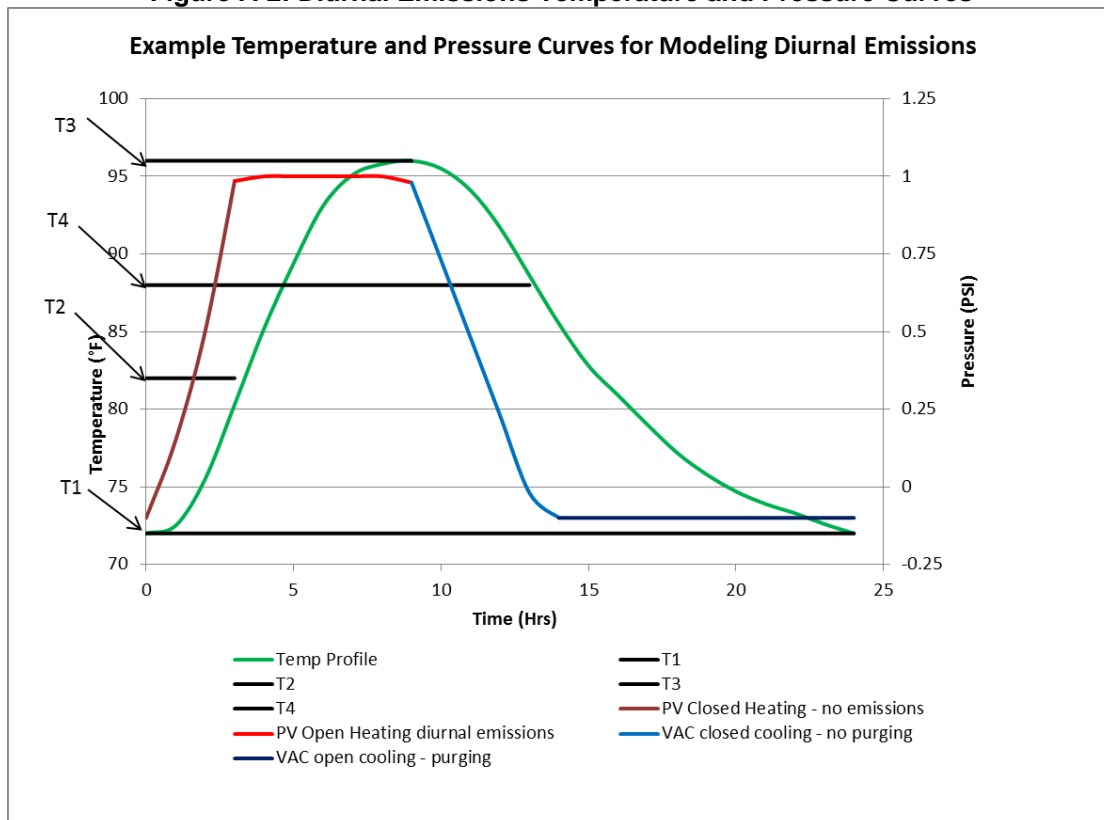


Figure A-2: Diurnal Emissions Temperature and Pressure Curves



10.2.1 Vehicle and Test Parameters

a. Fuel Volume Information

_____	(gal)	V_t	Total Volume of Fuel Tank
_____	(gal)	V_u	Usable Volume of Fuel Tank
_____	(gal)	V_i	Initial Fill Volume of Fuel Tank
_____	(gal)	V_{FP}	Fuel Used During Prep
_____	(gal)	V_{FR}	Fuel Used During Run Loss

EXAMPLE:

<u>2.1</u>	(gal)	V_t	Total Volume of Fuel Tank
<u>2</u>	(gal)	V_u	Usable Volume of Fuel Tank
<u>1</u>	(gal)	V_i	Initial Fill Volume of Fuel Tank
<u>0.1</u>	(gal)	V_{FP}	Fuel Used During Prep
<u>0.1</u>	(gal)	V_{FR}	Fuel Used During Run Loss

b. List of Temperatures

T1 (°K) = Initial/Final Diurnal Temperature
T2 (°K) = Temperature where Pressure Relief Valve Opens

T3 (°K) = Highest Diurnal Temperature
T4 (°K) = Temperature at which vacuum valve opens

c. Pressure Control Settings

<u>2.1</u>	(psig)	P _{VO}	Opening Pressure
<u>2</u>	(psig)	VAC _{VO}	Vacuum Opening Pressure

EXAMPLE:

<u>1</u>	(psig)	P _{VO}	Opening Pressure
<u>0.1</u>	(psig)	VAC _{VO}	Vacuum Opening Pressure

d. Fuel Reid Vapor Pressure

<u> </u>	RVP
-------------------	-----

EXAMPLE:

<u>7</u>	RVP
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e. Carbon Canister Specifications

<u> </u>	(cc)	BV	Bed Volume
<u> </u>	(g/canister)	TBWC	Total Butane Working Capacity of Canister
<u> </u>	(g/100cc)	BWC	Butane Working Capacity of Carbon
<u> </u>	(g/100cc)	GCPV	Gasoline Capacity per Volume of Carbon (at 96°F)

EXAMPLE:

<u>80</u>	(cc)	BV	Bed Volume
<u>12</u>	(g/canister)	TBWC	Total Butane Working Capacity of Canister
<u>15</u>	(g/100cc)	BWC	Butane Working Capacity of Carbon
<u>20</u>	(g/100cc)	GCPV	Gasoline Capacity per Volume of Carbon

f. Determine the Maximum Gasoline Vapor Capacity(MGVC) of Canister

The Maximum Gasoline Vapor Capacity is the total mass of gasoline vapor that a purged canister can expect to hold. MGCV is determined by direct measurement similar to BWC but using vapor from gasoline at 96°F instead of butane, or by calculating MGVC using canister volume, BWC and GVPV.

Maximum Gasoline Vapor Capacity (MGVC) of Canister

$$\text{MGVC} = \text{GCPV} / \text{BWC} * \text{TBWC} = \underline{\hspace{1cm}} / \underline{\hspace{1cm}} * \underline{\hspace{1cm}}$$

Where,
GCPV, BWC, TBWC = (From section 10.2.1.e)

EXAMPLE:

$$MGVC = GCPV/BWC * TBWC = 20/15 * 12 = 16g/canister$$

- g. Determine Vapor Space Volume of Fuel Tank at end of all Prep Cycles (V_p)

$$V_p = V_t - V_i + V_{pf} + V_{fr}$$

$$V_p = \underline{\hspace{1cm}} - \underline{\hspace{1cm}} + \underline{\hspace{1cm}} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$$

Where,

V_t, V_i, V_{pf}, V_{fr} = (From section 10.2.1.a)

EXAMPLE:

$$V_p = 2.1 - 1 + 0.1 + 0.1 = 1.3$$

- h. Determine Carbon Canister Gasoline Vapor Capacity at Beginning of Diurnal

The Carbon Canister Gasoline Vapor Capacity at Beginning of Diurnal is the total mass of gasoline vapor that the canister can expect to hold at the beginning of the diurnal. GVC_{di} is determined by direct measurement similar to BWC (section 6.3.5) but using vapor from gasoline at 96°F instead of butane, or by calculating MGVC using canister volume, BWC and GVPV.

GVC_{di} = measured gasoline vapor capacity at beginning of diurnal

$$GVC_{di} = GCPV/BWC * GVC_{di}(\text{butane}) = \underline{\hspace{1cm}} / \underline{\hspace{1cm}} * \underline{\hspace{1cm}}$$

$$GVC_{di} = \underline{\hspace{1cm}}$$

EXAMPLE:

$$GVC_{di} = 10g$$

10.2.2 Determining Diurnal Vapor Generation

Vapor generation occurs as a result of temperature increase of the fuel in the fuel tank. Vapor emissions occur when the generated vapor is able to exit the fuel tank. If the system does not use a pressure relief system vapor emissions will occur during the entire diurnal heating stage from 72°F to 96°F. If the system uses a pressure relief system the emissions occur only from the temperature corresponding to the fuel tank pressure equaling the relief pressure. If such a system is employed the temperature at which the relief valve opens must be determined.

- a. Calculate gasoline vapor pressure at lowest temperature of diurnal cycle (72°F/22.2°C)

Vapor pressure

$$P_{tgasoline}(T1) = A * T1 * RVP * e^{\frac{-B}{T1}}$$

Where,
 $T1 = 22.2\text{ C} + 273.2\text{ K} = 295.4\text{ K}$
 $A = 25.61$
 $B = 2789.78$
 $RVP = (\text{From section 10.2.1.d})$

EXAMPLE:

$$P_{tgasoline}(72\text{ F}) = 25.61 * 295.4 * 7 * e^{\frac{-2789.79}{295.4}} = 4.19\text{ psi}$$

- b. Determine partial pressure of air in the fuel tank at lowest temperature of diurnal cycle.

$$P_{air}(72\text{ F}) = P_{atm} - VAC_{vo} - P_{tgasoline}(72\text{ F})$$

Where,
 $P_{atm} = 14.7\text{ psi}$
 $VAC_{vo} = (\text{From section 10.2.1.c})$
 $P_{tgasoline}(72\text{ f}) = (\text{From section 10.2.2.a})$

$$P_{air}(72\text{ F}) = 14.7 - \text{_____} - 4.16 = \text{_____}$$

EXAMPLE:

$$P_{air}(T1) = 14.7 - 0.1 - 4.19 = 10.4\text{ psi}$$

Find the temperature (T2) at which the relief valve opens. This will be where the internal tank pressure equals atmospheric pressure plus the relief valve pressure. If no pressure control system is used T2 equals 72°F.

Solve using numerical analysis.

$$P_{tank}(vac\text{ open}) = P_{atm} + P_{vo} = P_{tgasoline}(T2) + P_{air}(T2)$$

Where,
 $P_{tgasoline}(T2) = A * T2 * RVP * e^{\frac{-B}{T2}}$
 $RVP = (\text{From section 10.2.1.d})$
 $P_{vo} = (\text{From section 10.2.1.c})$

$$P_{air}(T2) = \frac{T2 * P_{air}(T1)}{T1}$$

$$T2 = \text{_____}$$

EXAMPLE:

Assume $82^\circ\text{F} = 301^\circ\text{K}$
 $P_{tgasoline}(301\text{K}) = 25.61 * 301 * 7 * e^{(2789.78/301)} = 5.1\text{ psi}$
 $P_{air}(301\text{K}) = (301 * 10.4) / 295.4 = 10.6$

$$P_{\text{gasoline}}(301K) + P_{\text{air}}(301K) = 10.6 + 5.1 = 15.7 \text{ psi}$$

$$T_2 = 82^\circ\text{F}$$

- c. Using the Reddy Vapor Generation equation, determine the vapor generation in grams per gallon for a diurnal cycle from T2, for systems with pressure relief, to T3.

$$VAPOR_{\text{diurnal}} = C * e^{D * RVP} * (e^{E * T_3} - e^{E * T_2})$$

Where,

$$C = 0.00817$$

$$D = 0.2357$$

$$E = 0.0409$$

$$T_2 (F) = (\text{From section 10.2.2.c, converted to } ^\circ\text{F})$$

$$T_3 (F) = \text{max diurnal } (96^\circ\text{F})$$

$$V_p = (\text{From section 10.2.1.g})$$

$$RVP = (\text{From section 10.2.1.d})$$

Vapor generation for a non-pressurized system using a 72°F- 96°F temperature profile at sea level with 7 RVP fuel simplifies to:

$$VAPOR_{\text{diurnal}} = 1.35 \text{ g/gal}$$

EXAMPLE:

$$VAPOR_{\text{diurnal}} = 0.00817 * e^{(0.2357 * 7)} * (e^{(0.0409 * 96)} - e^{(0.0409 * 82)}) = 0.94 \text{ g/gal}$$

10.2.3 Determine Carbon Canister Back-Purge during the diurnal cooling

The weight of hydrocarbon vapor purged from the carbon canister during diurnal cooling steps is a function of the volume of air drawn into the fuel tank as it cools, and how efficiently that air takes up vapor from the canister. Good canister design increases the effectiveness of this process. The amount of air purging the canister will be the difference between the air volume in the fuel tank at the end of cooling less the amount in the tank when the air first begins to enter the tank. In a system that does not employ a pressure relief/vacuum valve system the flow of air begins as soon as the cooling starts. In a system that employs pressure control the air flow begins when the in tank pressure equals atmospheric pressure less the opening pressure of the vacuum valve. The following calculations provide a calculation method appropriate for either type of system.

- a. Calculate gasoline vapor pressure at highest temperature of diurnal cycle (96 °F/36.6°C)

Vapor pressure

$$P_{\text{gasoline}}(96 F) = A * T_3 * RVP * e^{\frac{-B}{T_3}}$$

Where,

$$T3 = 35.6\text{ }^{\circ}\text{C} + 273\text{ K} = 308.75\text{ K}$$

$$A = 25.61$$

$$B = 2789.78$$

$$RVP = (\text{From section 10.2.1.d})$$

EXAMPLE:

$$P_{tgasoline}(96\text{ }^{\circ}\text{F}) = 25.61 * 308.75 * 7 * e^{\frac{-2789.78}{308.75}} = 6.59\text{ psi}$$

- b. Determine Partial Pressure of Air in the fuel tank at highest temperature of diurnal cycle.

$$P_{air}(96\text{ }^{\circ}\text{F}) = P_{atm} + P_{vo} - P_{tgasoline}(96\text{ }^{\circ}\text{F})$$

Where,

$$P_{atm} = 14.7\text{ psi}$$

$$P_{vo} = (\text{From section 10.2.1.c})$$

$$P_{air}(96\text{ }^{\circ}\text{F}) = 14.7 + \text{_____} - 6.59 =$$

EXAMPLE:

$$P_{air}(96\text{ }^{\circ}\text{F}) = 14.7 + 1 - 6.59 = 9.11\text{ psi}$$

Find the temperature (T4) at which the vacuum valve opens. This will be where the internal tank pressure equals atmospheric pressure less the vacuum valve setting. This temperature may be found using numerical analysis. If no pressure control system is used this temperature will be 96°F.

$$P_{tank}(vac\text{ open}) = P_{atm} - VAC_{vo} = P_{tgasoline}(T4) - P_{air}(T4)$$

Where,

$$P_{tgasoline}(T4) = A * T4 * RVP * e^{\frac{B}{T4}}$$

$$P_{air}(T4) = \frac{T4 * P_{air}(T3)}{T3}$$

Where,

$$RVP = (\text{From section 10.2.1.d})$$

$$P_{air}(T3) = (\text{From section 10.2.3.b})$$

$$VAC_{vo} = (\text{From section 10.2.1.c})$$

Solve for T4

$$T4 = \text{_____}$$

EXAMPLE:

$$\text{Assume } 88\text{ }^{\circ}\text{F} = 304.1\text{ }^{\circ}\text{K}$$

$$P_{tgasoline}(304.1\text{ K}) = 25.61 * 304.1 * 7 * e^{(2789.78/304.1)} = 5.6\text{ psi}$$

$$P_{air}(304.1\text{ K}) = (304.1 * 10) / 308.56 = 9.0\text{ psi}$$

$$P_{tgasoline}(304.1\text{ K}) + P_{air}(304.1\text{ K}) = 9.0 + 5.6 = 14.6\text{ psi}$$

$$T2 = 88\text{ }^{\circ}\text{F}$$

- c. Determine the volume of air in the fuel tank in gallons at the temperature when the vacuum valve opens.

$$V_{air}(T4) = \frac{V_p * P_{air}(T4)}{(P_{atm} - VAC_{vo})}$$

Where,

$P_{tgasoline}(T4)$ = (From section 10.2.3.c)

VAC_{vo} = (From section 10.2.1.c)

V_p = (From section 10.2.1.g)

EXAMPLE:

$$V_{air}(T4) = \frac{1.3 * 9.1}{(14.7 - 0.1)} = 0.8 \text{ gal}$$

- d. Determine the volume of air in the fuel tank in gallons at the minimum temperature of the diurnal cycle ($T1=72^\circ\text{F}$).

$$V_{air}(T1) = \frac{V_p * P_{air}(T1)}{(P_{atm} - VAC_{vo})}$$

$$V_{air}(T1) = \frac{*}{(14.7 - VAC_{vo})}$$

Where,

$P_{air}(T1) = P_{air}(72^\circ\text{F})$ (From section 10.2.2.b)

VAC_{vo} = (From section 10.2.1.c)

V_p = (From section 10.2.1.g)

EXAMPLE:

$$V_{air}(T1) = \frac{1.3 * 10.43}{(14.7 - 0.1)} = 0.92 \text{ gal}$$

- e. The volume of air purging the carbon canister in gallons is the difference between these volumes.

$$V_{airpurge} = V_{air}(T1) - V_{air}(T4)$$

$$V_{airpurge} = \text{-----} - \text{-----}$$

Where,

$V_{airpurge(cc)} = V_{airpurge} * 3785.4 \text{ cc/gal}$

$V_{air}(T4)$ = (From section 10.2.3.e)

$V_{air}(T1)$ = (From section 10.2.3.f)

EXAMPLE:

$$V_{airpurge} = V_{air}(T1) - V_{air}(T4) = 0.92 - 0.8 = 0.12 \text{ gal}$$

$$V_{airpurge(cc)} = 0.12 \text{ gal} * 3785.4 \text{ cc/gal} = 454.2 \text{ cc}$$

- f. Calculate the purge Bed Volume(s).

$$BV_{\text{purge}} = \frac{V_{\text{airpurge(cc)}}}{BV_{\text{carbon}}}$$

Where,

BV_{carbon} = Total Volume of Carbon Canister (From section 10.2.1.e)

$V_{\text{airpurge(cc)}}$ = (From section 10.2.3.f)

$$BV_{\text{purge}} = \text{---} = \text{---}$$

EXAMPLE:

$$BV_{\text{purge}} = 454.2/80 = 5.68 \text{ bed volumes}$$

The efficiency of the back purge changes based on how heavily loaded the canister is when the purge takes place. Empirical data must be generated for the conditions at the beginning of the diurnal test.

EXAMPLE:

A purge efficiency of 0.15% of the total canister TBWC per bed volume purged.

$$\begin{aligned} VAPOR_{\text{backpurge}} &= 0.0015 * TBWC * GCPV / BWC * BV_{\text{purge}} \\ VAPOR_{\text{backpurge}} &= 0.0015 * 12 * 20/15 * 5.68 = 0.136g \end{aligned}$$

Where,

$TBWC$ = (From section 10.2.1.e)

BWC = (From section 10.2.1.e)

$GCPV$ = (From section 10.2.1.e)

BV_{purge} = (from section 10.2.3.g)

10.2.4 Calculating Compliance

- a. Maximum Total Diurnal Vapor Load on the canister over the three cycles is:

$$\begin{aligned} VL_{\text{diurnaltot}} &= 3 * (VAPOR_{\text{diurnal}} * VP) - (2 * VAPOR_{\text{backpurge}}) \\ VL_{\text{diurnaltot}} &= 3 * (\text{---} * \text{---}) - (2 * \text{---}) = \text{---} \end{aligned}$$

Where,

$VAPOR_{\text{diurnal}}$ = (From section 10.2.2.d)

$VAPOR_{\text{backpurge}}$ = (From section 10.2.3.g)

EXAMPLE:

$$VL_{\text{diurnaltot}} = 3 * (0.94 * 1.3) - (2 * 0.136) = 3.4g$$

- b. Total Canister Loading is:

$$VL_{\text{total}} = MGVC - GVC_{\text{di}} + VL_{\text{diurnaltot}}$$

Where,

$MGVC$ = (From section 10.2.1.f)

GVC_{di} = (From section 10.2.1.h)

$VL_{\text{diurnaltot}}$ = (From section 10.2.4.a)

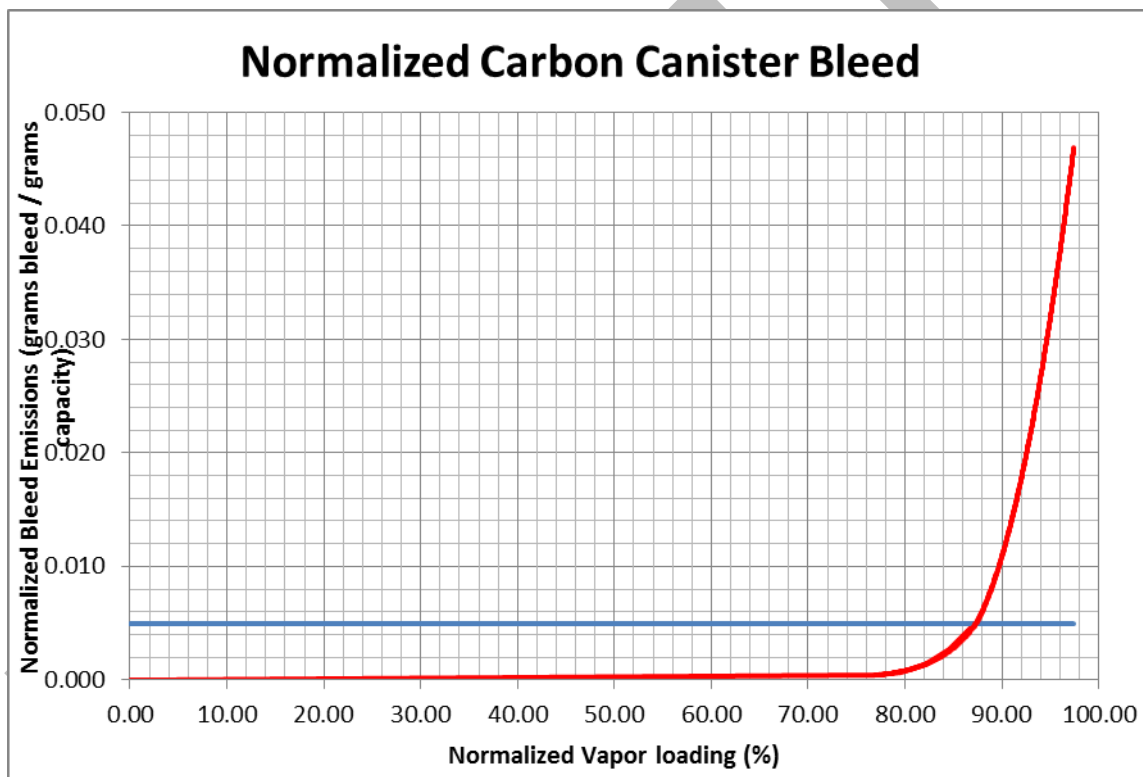
$$VL_{\text{total}} = \text{---} - \text{---} + \text{---} = \text{---}$$

EXAMPLE:

$$VL_{total} = 16 - 10 + 3.4 = 9.4g$$

Criteria for approval of Certification- A graph similar to the one shown below, but appropriate for the carbon canister actually used, must be submitted. The x axis must show the loading of the canister as a percentage of its working capacity. The y axis must show the bleed emissions in grams of bleed per grams of working capacity when the canister is loaded at the rate defined in section 5.2.1 (50/50 mixture by volume of butane and nitrogen at a rate of 15 ± 2 grams butane per hour per liter of canister volume).

Figure A-3: EXAMPLE plot



Acceptable design (sizing) of the canister shall be demonstrated by a calculated Total Canister Loading (VL_{total}) that is the lesser of 75% of the Normalized Loading or that Normalized Loading where the efficiency of the canister to control Bleed Emissions exceeds 0.005 grams of bleed emission / gram of total canister capacity (MVL%).

Normalized Load Limit Percentage:

$$NVL\% = \frac{\text{MAE}}{\text{MVL}} \times 100$$

Normalized Load:

$$NVL = NVL\% \times MGVC$$

Where,

MGVC = (From section 10.2.1.f)

EXAMPLE:

$NVL\% = 75$

$NVL = 0.75 * 16 = 12g$

c. The design is acceptable if:

$NVL > VL_{total}$

$\frac{12g}{16g} > \frac{9.4g}{16g}$

EXAMPLE:

$12g > 9.4g, \dots \text{PASS!}$

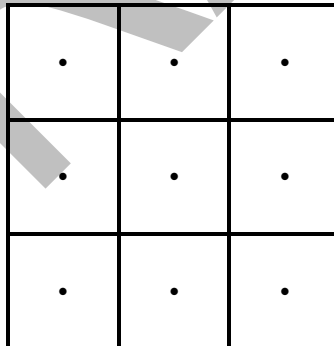
10.3 Appendix C – Motorcycle Variable Speed Cooling Blower

- a) Variable speed cooling blower must direct air to the vehicle.
- b) Blower outlet must be at least 0.4 meter² (4.31 feet²).
- c) Blower outlet must be squarely positioned 0.3 ± 0.05 meter (11.8 ± 1.97 inch) in front of the vehicle.
- d) Blower outlet lower edge height must be 0.1 meter (3.94 inch) to 0.2 meter (7.87 inch) above the ground.
- e) Cooling air speed produced by the blower must be within the following limits (as a function of roll speed):

Actual roll speed	Allowable cooling air speed
0 km/h	0 km/h
Above 0 km/h to 5 km/h	0 km/h to roll speed + 2.5 km/h
Above 5 km/h to 25 km/h	Roll speed \pm 2.5 km/h
25 km/h to 80 km/h	Roll speed \pm 10 percent
Above 80 km/h	At least 72 km/h

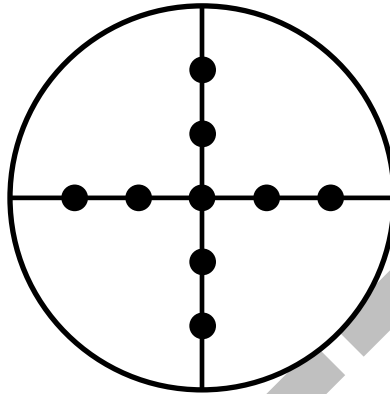
- f) The cooling air speed above must be determined as an averaged value of 9 measuring points.
 - 1) For blowers with rectangular outlets, both horizontal and vertical sides of the blower outlet must be divided into 3 equal parts yielding 9 equal rectangular areas (see the diagram below). The measurement points are located at the center of each rectangular area.

Figure A-4



- 2) For blowers with circular outlets, the blower outlet must be divided into 4 equal sectors defined by a vertical line and a horizontal line (see diagram below). The measurement points include the center of the blower outlet and locations on the radial lines (0° , 90° , 180° , and 270°) at radii of $1/3$ and $2/3$ of the total radius.

Figure A-5



- g) In addition to the averaged cooling air speed requirements, each measuring point must be within ± 30 percent of actual roll speeds above 5 km/h.
- h) Cooling air speed must be measured linearly at a distance of 0.3 meter (11.8 inch) ± 2 percent from the blower outlet.
- i) Cooling air speed measurements must be made with no vehicle or other obstruction in front of the blower outlet.
- j) Instrument used to measure and verify cooling air speed must have an accuracy of 2 percent.